

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
15 March 2001 (15.03.2001)

PCT

(10) International Publication Number
WO 01/18055 A1

(51) International Patent Classification⁷: C07K 14/705, (74) Agents: WEBSTER, Thomas, D. et al.; Lilly Corporate
1/14, A61K 38/17, 47/02 Center, Indianapolis, IN 56285 (US).

(21) International Application Number: PCT/US00/20807

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(22) International Filing Date: 31 August 2000 (31.08.2000)

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

(25) Filing Language: English

(26) Publication Language: English

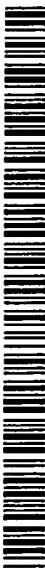
Published:

— With international search report.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(72) Inventors; and

(75) Inventors/Applicants (for US only): ATKINSON, Paul, Robert [US/US]; 4514 Lakeridge Drive, Indianapolis, IN 46234 (US). TIAN, Yu [CN/US]; 13695 Flintridge Pass, Carmel, IN 46033 (US). WITCHER, Derrick, Ryan [US/US]; 10898 Parrot Court, Fishers, IN 46038 (US).



A1

(54) Title: FLINT ANALOG COMPOUNDS AND FORMULATIONS THEREOF

(57) Abstract: The present invention provides novel compounds, which comprise a FLINT analog complexed with a divalent metal cation, pharmaceutical formulations thereof, and methods of using such compounds for treating or preventing diseases related to the FasL/Fas interaction.

FLINT ANALOG COMPOUNDS AND FORMULATIONS THEREOF

Background of the Invention

5 The present invention is in the field of human medicine, particularly in the treatment and prevention of disorders that may be associated with the binding of FasL to the Fas receptor. More specifically, the present invention relates to compounds and formulations of a FLINT analog.

10 A number of tumor necrosis factor receptor proteins ("TNFR proteins") and proteins homologous thereto have been isolated in recent years. They have many potent biological effects and aberrant activity of these proteins has been implicated in a number of disease states.

15 One such TNFR homologue, reported in July, 1998 (Gentz et al., WO 98/30694), binds the protein FAS Ligand and thereby inhibits the activation of another TNFR homologue, FAS, by FAS Ligand (U.S. Provisional Applications Serial Nos. 60/112,577, 60/112,933, and 60/113,407, filed 20 December 17, 18 and 22, 1998, respectively). This new protein is referred to herein as "FAS Ligand Inhibitory Protein" or "FLINT."

25 Over activation of FAS by FAS Ligand has been implicated in a number of pathological conditions, including runaway apoptosis (Kondo et al., *Nature Medicine* 3(4):409-413 (1997) and Galle et al., *J. Exp. Med.* 182:1223-1230 (1995)) and inflammatory disease resulting from neutrophil activation (Miwa et al., *Nature Medicine* 4:1287 (1998)).

30 "Runaway apoptosis" is a level of apoptosis greater than normal or apoptosis occurring at an inappropriate time. Pathological conditions caused by runaway apoptosis include organ failure, for example in the liver, kidneys and pancreas. Inflammatory diseases

-2-

associated with excessive neutrophil activation include, but are not limited to, sepsis, ARDS, SIRS and MODS.

The structural properties of proteins may be affected by divalent cations. For example, aggregation and/or precipitation of proteins, as well as oligomerization, may be induced by divalent cations. Aggregation of proteins can impact the ability to produce, purify, formulate and deliver a protein, for example, as a pharmaceutical product. Moreover, aggregation and/or oligomerization can impact the stability of a protein, for example, in storage. In some instances, a protein's stability can be enhanced if aggregated and/or precipitated prior to, or during storage.

FLINT and analogs thereof, for example, analog R218Q, aggregate and eventually precipitate from solution when exposed to divalent cation. For example, analog R218Q purified by IMAC chromatography and elution in 0.4M imidazole, precipitates from solution (See Example 7, *infra*). These observations suggest that FLINT and analogs thereof interact with divalent cations, such as Ni^{+2} , to cause aggregation and/or precipitation.

As FLINT analogs are potentially useful therapeutic proteins, their purification and formulation are important factors to be worked out on the path to development of a pharmaceutical product. While FLINT is known from prior disclosures (See e.g WO 98/30694 and WO 99/50413), its formulation has not been thoroughly investigated, nor has the impact of divalent cation on the aggregation and/or oligomerization of the protein and its analogs been sufficiently investigated for purposes of realizing the full therapeutic and pharmaceutical utility.

-3-

The present invention relates to a method for eliminating aggregation and/or precipitation of FLINT analog(s), useful in purifying one or more FLINT analogs comprising the removal of divalent cation from a solution 5 or other medium comprising FLINT analog(s).

The invention relates further to the purification of FLINT analogs from a solution of one or more of said FLINT analogs, by immobilized metal ion affinity (IMAC) chromatography, comprising removal of divalent cation from 10 said solution.

The invention relates further to a composition comprising a FLINT analog and a divalent metal cation.

The invention relates further to a method for producing a composition comprising FLINT analog, in 15 association with a divalent cation.

The present invention relates further to a pharmaceutical formulation comprising FLINT analog, in association with a divalent metal cation, and with one or more pharmaceutically acceptable carriers, diluents, or 20 excipients.

Accordingly, the present invention provides a FLINT analog-divalent cation complex, which comprises a FLINT analog complexed with a divalent metal cation, pharmaceutical formulations thereof, and methods for using 25 such pharmaceutical formulations thereof, and methods of using such compounds for the treatment and/or prevention of disorders that may be associated with the binding of Fas to FasL, and/or LIGHT to the LT β R and/or TR2/HVEM receptors.

Compounds such as FLINT which inhibit the binding 30 of FAS to FAS Ligand or LIGHT to LT β R and/or TR2/HVEM receptors can be used to treat or prevent diseases or conditions associated with these binding interactions.

-4-

Exemplary FLINT analogs of the invention suitable for formulation with a divalent cation have an amino acid sequence of SEQ ID NO: 1, modified by:

- 5 a) replacing tryptophan at position 53 with aspartic acid;
- b) replacing threonine at position 88 with proline;
- c) replacing alanine at position 107 with serine, aspartic acid, glutamic acid or threonine;
- d) replacing isoleucine at position 110 with threonine or glutamic acid; or
- 10 e) replacing proline at position 104 with serine.

In another aspect, a FLINT analog has an amino acid sequence of SEQ ID NO: 1, modified by:

- 15 a) replacing alanine at position 2 or position 12 with asparagine;
- b) replacing proline at position 25, position 38, position 126 or position 171 with asparagine;
- c) replacing arginine at position 35 with asparagine;
- d) replacing serine at position 37 with asparagine and proline at position 38 with any other naturally occurring amino acid;
- 20 e) replacing serine at position 166 with asparagine;
- f) replacing leucine at position 172 with asparagine;
- g) replacing aspartic acid at position 194 with asparagine;
- 25 h) replacing glycine at position 114 with asparagine and proline at position 115 with any naturally occurring amino acid; or
- i) replacing arginine at position 218 with asparagine.

30 In yet another aspect, a FLINT analog has an amino acid sequence of SEQ ID NO: 1, modified by:

-5-

- a) replacing asparagine at position 63 with tryptophan;
- b) replacing glycine at position 67 with aspartic acid and replacing alanine at position 94 or glycine at 5 position 95 with tyrosine;
- c) replacing arginine at position 69 with glutamic acid;
- d) replacing arginine at position 82 with glutamic acid or threonine;
- 10 e) replacing alanine at position 94 with tyrosine and replacing glycine at position 95 with aspartic acid;
- f) replacing phenylalanine at position 96 with glutamine;
- 15 g) replacing alanine at position 101 with threonine; or h) replacing glycine at position 95 with aspartic acid.

In yet another aspect, a FLINT analog has an amino acid sequence of SEQ ID NO: 1, modified by:

- a) replacing arginine at position 10 with glutamine, asparagine, serine or threonine, provided that 20 when the replacing amino acid is asparagine, then alanine at position 12 is optionally replaced with serine or threonine;
- b) replacing glutamic acid at position 13 with glutamine, asparagine, serine or threonine, 25 provided that when the replacing amino acid is asparagine, then glycine at position 15 is optionally replaced with serine or threonine;
- c) replacing glutamic acid at position 16 with glutamine, asparagine, serine or threonine, 30 provided that when the replacing amino acid is asparagine, then leucine at position 18 is optionally replaced with serine or threonine;
- d) replacing arginine at position 17 with glutamine, asparagine, serine or threonine, provided that 35 when the replacing amino acid is asparagine, then

-6-

valine at position 19 is optionally replaced with serine or threonine;

5 e) replacing arginine at position 31 with glutamine, asparagine, serine or threonine, provided that when the replacing amino acid is asparagine, then cysteine at position 33 is optionally replaced with serine or threonine;

10 f) replacing arginine at position 34 with glutamine, asparagine, serine or threonine, provided that when the replacing amino acid is asparagine, then aspartic acid at position 36 is optionally replaced with serine or threonine;

15 g) replacing arginine at position 35 with glutamine, asparagine, serine or threonine;

15 h) replacing aspartic acid at position 36 with glutamine, asparagine, serine or threonine, provided that when the replacing amino acid is asparagine, then proline at position 38 is optionally replaced with serine or threonine;

20 i) replacing arginine at position 143 with glutamine, asparagine, serine or threonine, provided that when the replacing amino acid is asparagine, then cysteine at position 145 is optionally replaced with serine or threonine; or

25 j) replacing aspartic acid at position 161 with glutamine, asparagine, serine or threonine, provided that when the replacing amino acid is asparagine, then leucine at position 163 is optionally replaced with serine or threonine.

30 Optional replacement by serine or threonine of an amino acid two positions removed from the replacing asparagine in the direction of the C-terminus creates new *N*-linked glycosylation site motifs, NXS/T. FLINT analogs with new glycosylation site motifs are preferably prepared

35 from recombinant mammalian host cells that express a gene encoding said polypeptide, thereby preparing an *N*-

-7-

glycosylated product. Glycosylation site motifs are discussed in greater detail hereinbelow.

In yet another embodiment, the present invention relates to a FLINT analog-divalent cation complex 5 comprising SEQ ID NO:1 having the amino acid sequence modified by:

- a) replacing alanine at position 2, 12, 107, 179 or 10 209 with threonine;
- b) replacing threonine at position 4 or 162 with alanine;
- c) replacing valine at position 1 or isoleucine at 15 position 110 with methionine;
- d) replacing glutamic acid at position 13 with aspartic acid;
- e) replacing arganine at position 17 with tryptophan;
- f) replacing alanine at position 75 with proline;
- g) replacing serine at positione 102 with leucine;
- h) replacing glycine at position 169 with alanine;
- i) replacing glutamic acid at position 183 with lysine;
- 20 j) replacing glutamine at position 225 with arginine;
- k) replacing glycine at position 237 with glutamic acid; or
- l) replacing valine at position 270 with glycine, 25 said fragment comprising amino acids 49-165 of the polypeptide; and

physiologically acceptable salts thereof.

In another aspect, a FLINT analog-divalent complex comprises an amino acid sequence of SEQ ID NO:1 modified by:

- 30 a) replacing alanine at position 2 or alanine at position 12 with asparagine;

-8-

- b) replacing proline at position 25, or proline at position 38, or proline at position 126, or proline at position 171 with asparagine;
- 5 c) replacing arginine at position 35 with asparagine;
- d) replacing serine at position 37 with asparagine, and proline at position 38 with any naturally occurring amino acid;
- e) replacing serine at position 166 with asparagine;
- f) replacing leucine at position 172 with asparagine;
- 10 g) replacing aspartic acid at position 194 with asparagine;
- h) replacing threonine at position 114 with asparagine and proline at position 115 to any naturally occurring amino acid; or
- i) replacing arginine at position 218 with asparagine.

In yet another aspect, a FLINT analog-divalent cation complex has an amino acid sequence of SEQ ID NO: 1, modified by:

- 20 a) replacing alanine at position 12 with asparagine and optionally replacing glutamic acid at position 13 with glutamine;
- b) replacing arginine at position 34 with asparagine and replacing aspartic acid at position 36 with threonine;
- 25 c) replacing arginine at position 35 with asparagine and optionally replacing serine at position 37 with threonine;
- d) replacing serine at position 132 with asparagine and optionally replacing serine at position 134 with threonine;

-9-

- e) replacing aspartic acid at position 194 with asparagine and optionally replacing serine at position 196 with threonine;
- 5 f) replacing arginine at position 35 and aspartic acid at position 194 with asparagine;
- g) replacing alanine at position 12 with asparagine, optionally replacing glutamic acid at position 13 with glutamine, replacing aspartic acid at position 194 with asparagine and optionally replacing serine at position 196 with threonine;
- 10 h) replacing arginine at position 34 with asparagine, replacing aspartic acid at position 36 with threonine, replacing aspartic acid at position 194 with asparagine and optionally replacing serine at position 196 with threonine;
- 15 i) replacing arginine at position 35 and aspartic acid at position 194 with asparagine and replacing serine at position 37 and/or position 196 with threonine; or
- 20 j) replacing arginine at position 218 with glutamine.
- k) replacing glycine at position 26 with aspartic acid and replacing serine at position 132 with asparagine;
- 25 l) replacing alanine at position 12 with asparagine, replacing serine at position 132 with asparagine, and replacing serine at position 134 with threonine; or
- m) replacing threonine at position 216 with proline and replacing arginine at position 218 with glutamine.

-10-

The present invention provides conditions under which potency and/or stability of FLINT analogs may be significantly enhanced. Thus, effective pharmacological treatment may be achieved at lower doses thereby abrogating 5 toxic or other undesirable side effects. Accordingly, the present invention provides a protein-cation complex, which comprises a FLINT analog, or FLINT fusion protein comprising a FLINT analog complexed with a divalent metal cation.

10

Summary of the Invention

The invention provides a composition comprising a FLINT analog or fusion protein comprising a FLINT analog complexed with a divalent metal cation. The invention 15 additionally provides parenteral pharmaceutical formulations comprising a FLINT analog divalent cation composition and methods for using such compounds for treating or preventing diseases and disorders that may be associated with the binding of Fas to FasL, and/or LIGHT to 20 LT β R and/or TR2/HVEM receptors. The invention further provides a process of preparing such compounds, which comprises combining a FLINT analog or fusion protein comprising a FLINT analog and a divalent metal cation in an aqueous solution at a pH of about 4.5 to 9.0.

25

Detailed Description and Preferred Embodiments

For purposes of the present invention, as disclosed and claimed herein, the following terms and abbreviations are defined as follows:

30 The term "aggregate" or "aggregation" refers to a non-covalent association of protein or peptide molecules

-11-

including monomers, subunits, and fragments thereof, that may lead to precipitation of said molecules.

"FLINT protein analog," "FLINT analog," or "analog" refers to a protein derivative of mature FLINT (SEQ ID NO:1) or native FLINT (SEQ ID NO:2) comprising one or more amino acid deletions, additions, substitutions, inversions, or changes in the glycosylation pattern of residues within SEQ ID NO:1 or SEQ ID NO:2. Also included in the term are FLINT fusion proteins

10 "FLINT" is used herein to encompass FLINT analogs and FLINT fusion proteins.

"FLINT glycosylation mutant" or "glycosylation mutant" as used herein refers to amino acid changes in FLINT by which asparagine is substituted for the wild type residue to 15 create surface accessible glycosylation sites. Computer and homology models predict that these amino acid residues are on the surface of FLINT and are distinct from the site on FLINT that binds FAS Ligand and therefore contribute minimally to FLINT/FAS Ligand binding affinity. As a 20 consequence, it is expected that FLINT analogs obtained by replacing these surface accessible amino acid residues with asparagine would be glycosylated at the new glycosylation sites, would retain their affinity for FAS Ligand and will exhibit improved pharmaceutical and pharmacological 25 properties. Specifically, glycosylation mutants comprise modified FLINT polypeptides having an amino acid sequence of SEQ ID NO: 1, modified by:

- 30 a) replacing alanine at position 12 with asparagine and optionally replacing glutamic acid at position 13 with glutamine;
- b) replacing arginine at position 34 with asparagine and replacing aspartic acid at position 36 with threonine;

-12-

- c) replacing arginine at position 35 with asparagine and optionally replacing serine at position 37 with threonine;
- 5 d) replacing serine at position 132 with asparagine and optionally replacing serine at position 134 with threonine;
- e) replacing aspartic acid at position 194 with asparagine and optionally replacing serine at position 196 with threonine;
- 10 f) replacing arginine at position 35 and aspartic acid at position 194 with asparagine;
- g) replacing alanine at position 12 with asparagine, optionally replacing glutamic acid at position 13 with glutamine, replacing aspartic acid at position 194 with asparagine and optionally replacing serine at position 196 with threonine;
- 15 h) replacing arginine at position 34 with asparagine, replacing aspartic acid at position 36 with threonine, replacing aspartic acid at position 194 with asparagine and optionally replacing serine at position 196 with threonine;
- 20 i) replacing arginine at position 35 and aspartic acid at position 194 with asparagine and replacing serine at position 37 and/or position 196 with threonine;
- 25 j) replacing glycine at position 26 with aspartic acid and replacing serine at position 132 with asparagine;
- k) replacing alanine at position 12 with asparagine, replacing serine at position 132 with asparagine, and replacing serine at position 134 with threonine.

-13-

The term "fusion protein" or "FLINT fusion protein" as used herein refers to a FLINT protein or analog thereof wherein said protein or analog is fused to a 5 heterologous protein or peptide including a peptide tag useful in purification, e.g. a His-tag.

The term "negatively charged group" or "negatively charged amino acid" refers to Asp or Glu.

10 The term "positively charge group" or "positively charged amino acid" refers to His, Arg, or Lys.

The term "polar uncharged" or "polar uncharged amino acid" refers to Cys, Thr, Ser, Gly, Asn, Gln, and Tyr.

15 The term "nonpolar" or "nonpolar amino acid" refers to Ala, Pro, Met, Leu, Ile, Val, Phe, or Trp.

The term "naturally-occurring amino acid" refers to any of the 20 L-amino acids that are found in proteins.

20 "Treating" as used herein, describes the management and care of a patient for the purpose of combating the disease, condition, or disorder and includes the administration of a protein of the present invention to prevent the onset of the symptoms or complications, alleviating the symptoms or complications, or eliminating the disease, condition, or disorder.

25 "Isotonicity agent" refers to an agent that is physiologically tolerated and embarks a suitable tonicity to the formulation to prevent the net flow of water across the cell membrane. Compounds, such as glycerin, are commonly used for such purposes at known concentrations.

30 Other possible isotonicity agents include salts, e.g., NaCl, dextrose, and lactose.

-14-

The term "oligomer" or "oligomerization" refers to a specific interaction of more than one protein subunit in non-covalent or covalent fashion. Examples of specific oligomers would include dimers, trimers, tetramers, etc. As 5 used herein the term refers to association of one or more FLINT analogs including association of identical or non- identical subunits such as, for example, non-identical FLINT analogs in association. The process of oligomerization lies on a continuum with the process of 10 aggregation, the latter representing non-specific interactions, that in the extreme, lead to precipitation.

"Physiologically tolerated buffer" refers to buffers including TRIS, sodium acetate, sodium phosphate, or sodium citrate. The selection and concentration of 15 buffer is known in the art.

"Pharmaceutically acceptable preservative" refers to a multi-use parenteral formulation that meets guidelines for preservative effectiveness to be a commercially viable product. Pharmaceutically acceptable preservatives known 20 in the art as being acceptable in parenteral formulations include: phenol, m-cresol, benzyl alcohol, methylparaben, chlorobutanol, p-cresol, phenylmercuric nitrate, thimerosal and various mixtures thereof. Other preservatives may be found, e.g., in Wallhauser, K. H., Develop. Biol. Standard 25 24, 9-28 (Basel, S. Krager, 1974). The concentration necessary to achieve preservative effectiveness is dependent upon the preservative used and the conditions of the formulation.

As noted above, the invention provides a compound 30 comprising a FLINT analog complexed with a divalent metal cation.

-15-

Applicants have discovered that FLINT analogs undergo oligomerization and/or aggregation in the presence of divalent cations. In one aspect of the present invention, pharmaceutical compositions of FLINT analog and 5 divalent cation provide depot formulations for therapeutic use. In another aspect, oligomerization and/or aggregation of FLINT can be reduced, prevented, or reversed by removal of divalent cation from said protein. In this aspect, the invention relates to a process or method for purifying 10 FLINT and for maintaining FLINT in solution.

The presently claimed compounds comprise FLINT analogs complexed with a divalent metal cation. A divalent metal cation includes, for example, Zn^{+2} , Mn^{+2} , Fe^{+2} , Co^{+2} , Cd^{+2} , Ca^{+2} , Ni^{+2} and the like. A combination of two or more 15 divalent metal cations is operable; however the preferred compounds comprise a single species of metal cation, most preferably Zn^{++} . Preferably, the divalent metal cation is in excess; however, the molar ratio of at least one molecule of a divalent metal cation for each ten molecules 20 of FLINT analog is operable. Preferably, the compounds comprise from 1 to 100 divalent metal cations per molecule of FLINT analog. The compounds may be amorphous or crystalline solids.

Appropriate forms of metal cations are any form 25 of a divalent metal cation that is available to form a complex with a molecule of FLINT analog of the present invention. The metal cation may be added in solid form or it may be added as a solution. Several different cationic salts can be used in the present invention. Representative 30 examples of metal salts include the acetate, bromide, chloride, fluoride, iodide and sulfate salt forms. The skilled artisan will recognize that there are many other

-16-

metal salts which also might be used in the production of the compounds of the present invention. Preferably, zinc acetate or zinc chloride is used to create the zinc-FLINT analog compounds of the present invention. Most 5 preferably, the divalent metal cationic salt is zinc chloride.

Generally, the claimed compounds are prepared by techniques known in the art. For example, convenient preparation is to combine FLINT analog with the desired 10 divalent metal cation in an aqueous solution at a pH of about 4.5-9.0, preferably about pH 5.5-8, most preferably, pH 6.5-7.6. The claimed compound precipitates from the solution as a crystalline or amorphous solid.

Significantly, the compound is easily isolated and purified 15 by conventional separation techniques appreciated in the art including filtration and centrifugation.

Significantly, the protein-metal cation complex is stable and may be conveniently stored as a solid or as an aqueous suspension.

20 The present invention further provides a pharmaceutical formulation comprising a compound of the present invention and water. The concentration of the FLINT analog in the formulation is about 0.1 mg/mL to about 100 mg/mL; preferably about 0.5 mg/mL to about 50.0 mg/mL; 25 most preferably, about 5.0 mg/mL.

The formulation preferably comprises a pharmaceutically acceptable preservative at a concentration necessary to maintain preservative effectiveness. The relative amounts of preservative necessary to maintain 30 preservative effectiveness varies with the preservative used. Generally, the amount necessary can be found in

-17-

Wallhauser, K. H., Develop. Biol. Standard 24, 9-28 (Basel, S. Krager, 1974), herein incorporated by reference.

An isotonicity agent, preferably glycerin, may be added to the formulation. The concentration of the 5 isotonicity agent is in the range known in the art for parenteral formulations, preferably about 16 mg/mL glycerin. The pH of the formulation may also be buffered with a physiologically tolerated buffer. Acceptable physiologically tolerated buffers include TRIS, sodium 10 acetate, sodium phosphate, or sodium citrate. The selection and concentration of buffer is known in the art.

Other additives, such as a pharmaceutically acceptable excipients like Tween 20 (polyoxyethylene (20) sorbitan monolaurate), Tween 40 (polyoxyethylene (20) 15 sorbitan monopalmitate), Tween 80 (polyoxyethylene (20) sorbitan monooleate), Pluronic F68 (polyoxyethylene polyoxypropylene block copolymers), BRIJ 35 (polyoxyethylene (23) lauryl ether), and PEG (polyethylene glycol) may optionally be added to the formulation to 20 reduce aggregation.

The claimed pharmaceutical formulations are prepared in a manner known in the art, and are administered individually or in combination with other therapeutic agents. The formulations of the present invention can be 25 prepared using conventional dissolution and mixing procedures. Preferably, the claimed formulations are prepared in an aqueous solution suitable for parenteral use. That is, a protein solution is prepared by mixing water for injection, buffer, and a preservative. Divalent 30 metal cations are added to a total cation concentration of about 0.001 to 5.0 mg/mL, preferably 0.05 to 1.5 mg/mL. The pH of the solution may be adjusted to completely

-18-

precipitate the FLINT analog-cation complex. The compound is easily resuspended before administration to the patient.

Parenteral daily doses of the compound are in the range from about 1 ng to about 10 mg per kg of body weight, 5 although lower or higher dosages may be administered. The required dosage will be determined by the physician and will depend on the severity of the condition of the patient and upon such criteria as the patient's height, weight, sex, age, and medical history.

10 Variations of this process would be recognized by one of ordinary skill in the art. For example, the order the components are added, if a the surfactant is used, the temperature, and pH at which the formulation is prepared may be optimized for the concentration and means of 15 administration used.

The pH of the formulation is generally pH 4.5 to 9.0 and preferably 5.5 to 8.0, most preferably 6.5 to 7.6; although more acidic pH wherein a portion or all of the protein-metal cation complex is in solution is operable.

20 The formulations prepared in accordance with the present invention may be used in a syringe, injector, pumps or any other device recognized in the art for parenteral administration.

The proteins used in the present compounds can be 25 prepared by any of a variety of recognized peptide synthesis techniques including classical (solution) methods, solid phase methods, semi synthetic methods, and more recent recombinant DNA methods. Recombinant methods are preferred if a high yield is desired. The basic steps 30 in the recombinant production of protein include:

-19-

- a) construction of a synthetic or semi-synthetic (or isolation from natural sources) DNA encoding the FLINT analog,
- 5 b) integrating the coding sequence into an expression vector in a manner suitable for the expression of the protein either alone or as a fusion protein,
- 10 c) transforming an appropriate eukaryotic or prokaryotic host cell with the expression vector, and
- d) recovering and purifying the recombinantly produced protein.

A cDNA encoding native FLINT (SEQ ID NO:3) can provide a template from which to engineer specific mutations that result in a nucleic acid that encodes an analog of the invention. For example, FLINT cDNA is used as a template for introducing appropriate point mutations (i.e. construction of FLINT analog cDNAs). A suitable protocol is described in detail in "Current Protocols in Molecular Biology", volume 1, section 8.5.7 (John Wiley and Sons, Inc. publishers), incorporated herein by reference. Briefly, synthetic oligonucleotides are designed to incorporate one or more desired point mutation(s) at one end of an amplified fragment, e.g. at position 218 of SEQ ID NO:1. Following first strand PCR, the amplified fragments encompassing the mutation are annealed with each other and extended by mutually primed synthesis. Annealing is followed by a second PCR step utilizing 5' forward and 3' reverse end primers in which the entire mutagenized fragment gets amplified and is ready for subcloning into the appropriate vector.

-20-

Synthetic genes and nucleic acids can be constructed by techniques well known in the art. Owing to the degeneracy of the genetic code, the skilled artisan will recognize that multiple DNA sequences may be

5 constructed which encode the desired proteins. Synthesis is achieved by recombinant DNA technology or by chemical synthesis, for example, see Brown, et al. (1979) *Methods in Enzymology*, Academic Press, N.Y., Vol. 68, pgs. 109-151. A DNA sequence(s) encoding FLINT analogs can be generated

10 using a conventional DNA synthesizing apparatus such as the Applied Biosystems Model 380A or 380B DNA synthesizers (commercially available from Applied Biosystems, Inc., 850 Lincoln Center Drive, Foster City, CA 94404). It may be desirable in some applications to modify the coding

15 sequence of a FLINT analog so as to incorporate a convenient protease sensitive cleavage site, e.g., between the signal peptide and the structural protein facilitating the controlled excision of the signal peptide from the fusion protein construct.

20 A gene encoding FLINT analog(s) may also be created by using the polymerase chain reaction (PCR). The template can be a cDNA library, for example (commercially available from CLONETECH or STRATAGENE). Such methods are well known in the art, *c.f.* Maniatis, et al. Molecular

25 Cloning: A Laboratory Manual, Cold Spring Harbor Press, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York (1989), herein incorporated by reference.

The constructed or isolated DNA sequences are useful for expressing FLINT analog. When the sequences

30 comprise a fusion gene, the resulting product, if desired, can be treated enzymatically or chemically to release FLINT. A variety of peptidases which cleave a polypeptide

-21-

at specific sites or digest the peptides from the amino or carboxy termini (e.g. diaminopeptidase) of the peptide chain are known. Furthermore, particular chemicals (e.g. cyanogen bromide) will cleave a polypeptide chain at 5 specific sites. The skilled artisan will appreciate the modifications necessary to the amino acid sequence (and synthetic or semi-synthetic coding sequence if recombinant means are employed) to incorporate site-specific internal cleavage sites. See U.S. Patent No. 5,126,249; Carter P., 10 Site Specific Proteolysis of Fusion Proteins, Ch. 13 in Protein Purification: From Molecular Mechanisms to Large Scale Processes, American Chemical Soc., Washington, D.C. (1990).

Construction of suitable vectors containing the 15 desired coding and control sequences employ standard ligation techniques. Isolated plasmids or DNA fragments are cleaved, tailored, and religated in the form desired to form the plasmids required.

In general, plasmid vectors containing promoters 20 and control sequences which are derived from species compatible with the host cell are used with these hosts. The vector ordinarily carries a replication origin and one or more sequences for selection of transformed cells.

The desired coding sequence is inserted into an 25 expression vector in the proper orientation to be transcribed from a promoter and ribosome binding site, both of which should be functional in the host cell in which the protein is to be expressed.

In general, prokaryotes are used for cloning of 30 DNA sequences in constructing the vectors useful in the invention. For example, E. coli K12 strain 294 (ATCC No. 31446) is particularly useful. Other microbial strains

-22-

which may be used include E. coli B and E. coli X1776 (ATCC No. 31537). These examples are illustrative rather than limiting.

The DNA molecules may also be recombinantly
5 expressed in eukaryotic expression systems. Preferred
promoters controlling transcription in mammalian host cells
may be obtained from various sources, for example, the
genomes of viruses such as: polyoma, Simian Virus 40
(SV40), adenovirus, retroviruses, hepatitis-B virus and
10 most preferably cytomegalovirus, or from heterologous
mammalian promoters, e.g. β -actin promoter. The early and
late promoters of the SV40 virus are conveniently obtained
as an SV40 restriction fragment which also contains the
SV40 viral origin of replication. Fiers, et al., Nature,
15 273:113 (1978). The entire SV40 genome may be obtained
from plasmid pBRSV, ATCC 45019. The immediate early
promoter of the human cytomegalovirus may be obtained from
plasmid pCMBb (ATCC 77177). Of course, promoters from the
host cell or related species also are useful herein.

20 Transcription of the DNA by higher eucaryotes is
increased by inserting an enhancer sequence into the
vector. Enhancers are *cis*-acting elements of DNA, usually
about 10-300 bp, that act on a promoter to increase its
transcription. Enhancers are relatively oriented and
25 positioned independently and have been found 5' (Laimins,
L. et al., PNAS 78:993 (1981)) and 3' (Lusky, M. L., et
al., Mol. Cell Bio. 3:1108 (1983)) to the transcription
unit, within an intron (Banerji, J. L. et al., Cell 33:729
(1983)) as well as within the coding sequence itself
30 (Osborne, T. F., et al., Mol. Cell Bio. 4:1293 (1984)).
Many enhancer sequences are now known from mammalian genes
(globin, RSV, SV40, EMC, elastase, albumin, alpha-

-23-

fetoprotein and insulin). Typically, however, one will use an enhancer from a eukaryotic cell virus. Examples include the SV40 late enhancer, the cytomegalovirus early promoter enhancer, the polyoma enhancer on the late side of the 5 replication origin, and adenovirus enhancers.

Expression vectors used in eukaryotic host cells (yeast, fungi, insect, plant, animal, human or nucleated cells from other multicellular organisms) will also contain sequences necessary for the termination of transcription 10 which may affect mRNA expression. These regions are transcribed as polyadenylated segments in the untranslated portion of the mRNA encoding protein. The 3' untranslated regions also include transcription termination sites.

Expression vectors may contain a selectable 15 marker. Examples of suitable selectable markers for mammalian cells are dihydrofolate reductase (DHFR, which may be derived from the BglII/HindIII restriction fragment of pJOD-10 [ATCC 68815]), thymidine kinase (herpes simplex virus thymidine kinase is contained on the BamHI fragment 20 of vP-5 clone [ATCC 2028]) or neomycin (G418) resistance genes (obtainable from pNN414 yeast artificial chromosome vector [ATCC 37682]). When such selectable markers are successfully transferred into a mammalian host cell, the 25 transfected mammalian host cell can survive if placed under selective pressure. There are two widely used distinct categories of selective regimes. The first category is based on a cell's metabolism and the use of a mutant cell line which lacks the ability to grow without a supplemented media. Two examples are: CHO DHFR⁻ cells (ATCC CRL-9096) 30 and mouse LTK⁻ cells (L-M(TK-) ATCC CCL-2.3). These cells lack the ability to grow without the addition of such nutrients as thymidine or hypoxanthine. Because these

cells lack certain genes necessary for a complete nucleotide synthesis pathway, they cannot survive unless the missing nucleotides are provided in a supplemented media. An alternative to supplementing the media is to 5 introduce an intact DHFR or TK gene into cells lacking the respective genes, thus altering their growth requirements. Individual cells which were not transformed with the DHFR or TK gene will not be capable of survival in nonsupplemented media.

10 A suitable vector for eucaryotic expression is pRc/CMV. pRc/CMV is commercially available from Invitrogen Corporation, 3985 Sorrento Valley Blvd., San Diego, CA 92121. To confirm correct sequences in plasmids constructed, the ligation mixtures are used to transform E.

15 coli K12 strain DH10B (ATCC 31446) and successful transformants selected by antibiotic resistance where appropriate. Plasmids from the transformants are prepared, analyzed by restriction and/or sequence by the method of Messing, et al., Nucleic Acids Res. 9:309 (1981).

20 Host cells may be transformed with the expression vectors of this invention and cultured in conventional nutrient media modified as is appropriate for inducing promoters, selecting transformants or amplifying genes. The culture conditions, such as temperature, pH and the 25 like, are those previously used with the host cell selected for expression, and will be apparent to the ordinarily skilled artisan. The techniques of transforming cells with the aforementioned vectors are well known in the art and may be found in such general references as Maniatis, et

30 al., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Press, Cold Spring Harbor Laboratory, Cold Spring

-25-

Harbor, New York (1989), or Current Protocols in Molecular Biology (1989) and supplements.

Suitable host cells for expressing the vectors encoding the claimed proteins in higher eucaryotes include:

5 African green monkey kidney line cell line transformed by SV40 (COS-7, ATCC CRL-1651); transformed human primary embryonal kidney cell line 293, (Graham, F. L. et al., J. Gen Virol. 36:59-72 (1977), Virology 77:319-329, Virology 86:10-21); baby hamster kidney cells (BHK-21(C-13), ATCC 10 CCL-10, Virology 16:147 (1962)); Chinese hamster ovary cells CHO-DHFR⁻ (ATCC CRL-9096), mouse Sertoli cells (TM4, ATCC CRL-1715, Biol. Reprod. 23:243-250 (1980)); African green monkey kidney cells (VERO 76, ATCC CRL-1587); human cervical epitheloid carcinoma cells (HeLa, ATCC CCL-2);

15 canine kidney cells (MDCK, ATCC CCL-34); buffalo rat liver cells (BRL 3A, ATCC CRL-1442); human diploid lung cells (WI-38, ATCC CCL-75); human hepatocellular carcinoma cells (Hep G2, ATCC HB-8065); and mouse mammary tumor cells (MMT 060562, ATCC CCL51).

20 In addition, unicellular eukaryotes such as yeast may also be used. Saccharomyces cerevisiae, or common baker's yeast is the most commonly used eukaryotic microorganism, although a number of other strains are commonly available. For expression in Saccharomyces, the 25 plasmid YRp7, for example, (ATCC-40053, Stinchcomb, et al., Nature 282:39 (1979); Kingsman et al., Gene 7:141 (1979); Tschemper et al., Gene 10:157 (1980)) is commonly used. This plasmid already contains the trp gene which provides a selection marker for a mutant strain of yeast lacking the 30 ability to grow in tryptophan, for example ATCC no. 44076 or PEP4-1 (Jones, Genetics 85:12 (1977)).

Suitable promoting sequences for use with yeast hosts include the promoters for 3-phosphoglycerate kinase (found on plasmid pAP12BD ATCC 53231 and described in U.S. Patent No. 4,935,350, June 19, 1990) or other glycolytic enzymes such as enolase (found on plasmid pAC1 ATCC 39532), glyceraldehyde-3-phosphate dehydrogenase (derived from plasmid pHcGAPC1 ATCC 57090, 57091), zymomonas mobilis (United States Patent No. 5,000,000 issued March 19, 1991), hexokinase, pyruvate decarboxylase, phosphofructokinase, glucose-6-phosphate isomerase, 3-phosphoglycerate mutase, pyruvate kinase, triosephosphate isomerase, phosphoglucose isomerase, and glucokinase.

Other yeast promoters, which contain inducible promoters having the additional advantage of transcription controlled by growth conditions, are the promoter regions for alcohol dehydrogenase 2, isocytochrome C, acid phosphatase, degradative enzymes associated with nitrogen metabolism, metallothionein (contained on plasmid vector pCL28XhoLHPV ATCC 39475, United States Patent No. 4,840,896), glyceraldehyde 3-phosphate dehydrogenase, and enzymes responsible for maltose and galactose (GAL1 found on plasmid pRY121 ATCC 37658) utilization. Suitable vectors and promoters for use in yeast expression are further described in R. Hitzeman *et al.*, European Patent Publication No. 73,657A. Yeast enhancers such as the UAS Gal from Saccharomyces cerevisiae (found in conjunction with the CYC1 promoter on plasmid YEpsec--hIIbeta ATCC 67024), also are advantageously used with yeast promoters.

The following examples are provided to further illustrate the preparation of the formulations of the invention. The scope of the invention is not construed as merely consisting of the following examples.

-27-

EXAMPLE 1

Preparation of FLINT analog-Zinc Formulations

About 20 mg of a FLINT analog in which the arginine residue at position 34 of SEQ ID NO:1 is replaced by asparagine, the aspartic acid at position 36 is replaced by threonine, the aspartic acid at position 194 is replaced by asparagine, and the serine at position 196 is replaced by threonine (hereinafter referred to as "RDDS") is completely dissolved in 32 mL of an aqueous solution containing 16 mg/mL glycerin and 2 mg/mL phenol and passed through a sterile 0.2 μ filter. An aqueous solution containing 100 mg/mL of zinc in water is prepared from zinc chloride. Dilutions are made to prepare 10 mg/mL zinc and 1 mg/mL zinc solutions. Five 6-mL aliquots of the RDDS solution are mixed with the zinc solutions as shown in Table I:

Table I

Sample	mL of 1 mg/mL zinc added	ML of 10 mg/mL zinc added	ML of 100 mg/mL zinc added	ml of H ₂ O added	Total mg/mL zinc concentration
A	0	0	0	100	0
B	17	0	0	83	0.0027
C	0	33	0	67	0.054
D	0	0	19	81	0.30
E	0	0	92	8	1.50

20 Each formulation is adjusted to pH 7.48 \pm 0.03 using small volumes of 2N and 5N sodium hydroxide and stored at 4°C. Sample A is completely clear while samples B through E are cloudy suspensions.

-28-

EXAMPLE 2

Analysis of Zinc Formulations

Size-exclusion chromatography is performed on the centrifuged supernatants of Samples A through E of Example

5 1. For these analyses, 100 μ L of the supernatants are injected onto an analytical Superdex-75® (3.2/30, Pharmacia) column equilibrated in PBS (Dulbecco's Phosphate-Buffered Saline, GibcoBRL). The column is eluted at ambient temperature at 0.5 mL/min and the protein in the

10 eluant monitored at 214 nm.

EXAMPLE 3

Biological Activity of the Zinc Formulations

A FLINT analog bioassay measuring cell survival (i.e. prevention of apoptosis) is performed in a 96 well plate format with reactions of 100 μ l/well. 25 μ l of Jurkat cells (5×10^4 cells/well) is mixed with 25 μ l of recombinant human FasL (final concentration 150ng/ml) and 50 μ l of FLINT analog in Example 1. Cells are incubated at 37°C overnight.

15 Twenty μ l of MTS tetrazolium compound (U.S. Pat. No. 5,185,450 assigned to the Univ. of South Florida and exclusively licensed to Promega Corporation, Madison, WI) is added to each well and the incubation carried out for 2h at 37°C. Absorbance at 490 nm is recorded using a plate

20 reader.

25

EXAMPLE 4

Large Scale FLINT Analog Polypeptide Purification

Large scale production of a FLINT analog, RDDS

30 (containing a 6 histidine tag) is performed by growing stable pools in several roller bottles. After reaching confluence, cells are further incubated in serum-free medium

-29-

for 5 to 7 days to secrete maximum amount of FLINT analog into the medium. Media containing FLINT analog is adjusted to 0.1 % CHAPS concentrated in an Amicon ProFlux M12 tangential filtration system to 350 ml using an Amicon S3Y10

5 UF membrane. The concentrated media is passed over IMAC (Immobilized Metal-Affinity Chromatography (Pharmacia, 5 to 20 ml column) at a flow rate of 1 ml/min. The column is washed with buffer A (PBS (1 mM potassium phosphate, 3 mM sodium phosphate), 0.5 M NaCl, pH 7.4) until the absorbence

10 returns to baseline and the bound polypeptides is eluted with a linear gradient from 0.025 M to 0.5 M Imidazol (in buffer A) developed over 60 min. Fractions containing FLINT analog are pooled and EDTA is added to a final concentration of 50 mM EDTA. The pooled fractions containing FLINT analog

15 are concentrated using an Ultrafree centrifugal filter unit (Millipore, 10 kDa molecular weight cut-off) to 2 ml. This material is passed over a Superdex 75 (Pharmacia, 16/60) sizing column equilibrated with PBS, 0.5 M NaCl, pH 7.4, at a flow rate of 1 ml/min. Fractions containing FLINT analog

20 are analyzed by SDS-PAGE. The N-terminal sequence of FLINT analog is confirmed on the purified polypeptide.

EXAMPLE 5

Interaction of R34N D36T His-tagged FLINT Analog With Ni²⁺

25 FLINT analog R34N, D36T His-tagged (50 μ l) is incubated with NiCl₂ (final concentration of 1 mM) or with NiCl₂ and EDTA (both at a final concentration of 1 mM) for at 4 °C for 2 hours. As a control, R34N, D36T His-tagged FLINT is treated without the addition of NiCl₂ or EDTA.

30 After the incubation, the samples are centrifuged in an Eppendorf centrifuge at maximum speed for 5 min. 20 μ l of each sample is injected on to an analytical Superdex 75 column and eluted from this column at a flow rate of 70 μ l/min in PBS, 0.5 M NaCl, pH 7.4.

-30-

EXAMPLE 6

Effect of Divalent Cation on FLINT and Analogs

5 FLINT and FLINT analogs were purified from either AV12 or 293 cell lines. Protein samples were stored in PBS at pH 7.4, 0.5 M NaCl, and 10% glycerol. The effect of divalent cations, such as Ni^{2+} , Zn^{2+} and Ca^{2+} , was investigated using
10 intrinsic tryptophan fluorescence intensity and fluorescence anisotropy. Since fluorescence anisotropy is very sensitive to the rotational correlation time of the molecule, the change in the value of anisotropy reflects change in the association of FLINT molecules upon addition
15 of divalent cations.

Concentrations of FLINT or FLINT analogs were measured on an AVIV model 14DS spectrometer. Spectra were collected from 400 nm to 260 nm at 1-nm bandwidth and were corrected for the solvent and scatter using data obtained between 360
20 nm to 320 nm by the AVIV computer program Loggen. The peak absorbance at about 280 nm was divided by $0.786 \text{ mg}^{-1} \text{ cm}^{-1}$ to determine the concentration of the protein in a 1-cm pathlength cell. 5 mM NiCl_2 or ZnCl_2 or CaCl_2 stock solution was made by dissolving in H_2O the appropriate amount of
25 solid NiCl_2 , ZnCl_2 , or CaCl_2 .

30 Tryptophan fluorescence intensity and fluorescence anisotropy were measured using an ISS PCI photon counting spectrofluorometer. A protein solution of about 0.1 mg/ml concentration was excited at 295 nm and the total intensity of fluorescence and fluorescence anisotropy was recorded using a 335 nm cutoff filter in a cell of 5 mm x 10 mm pathlength with a 8 nm excitation bandwidth. A small aliquot of 5 mM NiCl_2 , ZnCl_2 , or CaCl_2 stock was added to the protein sample in the cell to adjust the

-31-

concentration of divalent cation concentration. The sample was then mixed by inverting the cuvette after each addition of divalent metal. The fluorescence signal intensity and anisotropy were determined as a function of divalent ion concentration.

The fluorescence intensity and anisotropy data obtained on FLINT as a function of NiCl_2 or ZnCl_2 is shown in Table I. Addition of either NiCl_2 or ZnCl_2 decreased the fluorescence intensity and increased the anisotropy, indicating an association of FLINT molecules. The association of FLINT molecules upon addition of ZnCl_2 is reversible by addition of 2 mM EDTA, as indicated by the decrease of anisotropy to the initial anisotropy value in the absence of ZnCl_2 .

15

Table I. Typtophan fluorescence intensity and anisotropy of FLINT as a function of NiCl_2 or ZnCl_2 concentration.

[NiCl_2] uM	Intensity	Anisotropy	[ZnCl_2] uM	Anisotropy
0	669978	0.1357	0	0.1344
5	648081	0.14	5	0.1304
10	628453	0.1368	10	0.1273
20	578457	0.1396	20	0.1342
40	548057	0.1416	40	0.1462
80	514699	0.1461	80	0.1724
100	457960	0.1527	100	0.1884
200	443962	0.1578	200	0.2172
400	361070	0.1671	400	0.2436
+ 2 mM EDTA	442029	0.1528	2 mM EDTA	0.1338

20 The effect of NiCl_2 and ZnCl_2 on His-tagged R218Q FLINT was also investigated. In contrast to FLINT, addition of small concentration of NiCl_2 or ZnCl_2 causes

-32-

precipitation of His-tagged R218Q, leading to the rapid increase of fluorescence anisotropy, as shown in Table II. The precipitation caused by $ZnCl_2$ can be readily reversed by addition of 2 mM EDTA. However, the precipitation by $NiCl_2$ 5 can only be reversed very slowly.

Table II. Fluorescence anisotropy of His-tagged R218Q FLINT as a function of $NiCl_2$ or $ZnCl_2$ concentration.

[$NiCl_2$] μM	Anisotropy	[$ZnCl_2$] μM	Anisotropy
0	0.1351	0	0.1299
5	0.1985	5	0.1360
10	0.214	10	0.2293
		+ 2 mM EDTA	0.1306

10 His-tagged analog RDDSR (i.e. R34N/D36T/D194N/S196T/R218Q) FLINT was purified from transiently-transfected 293EBNA cell line. This analog contains two additional putative asparagine-linked 15 glycosylation sites at Asn34 and Asn194. Fluorescence intensity and anisotropy as a function of divalent cation concentration are shown in Table III. In comparison to His-tagged R218Q, the hyperglycosylated His-tagged RDDSR is much less sensitive to $NiCl_2$. Addition of $NiCl_2$ up to 400 20 μM did not cause visible precipitation of protein. However, $ZnCl_2$ does cause the protein to precipitate, although to a lesser degree compared to His-tagged R218Q FLINT. The precipitated sample dissolved rapidly with addition of 1 mM EDTA and the anisotropy returned to the 25 initial value in the absence of $ZnCl_2$. All three cations, Ni^{2+} , Zn^{2+} , and Ca^{2+} , appear to bind the His-tagged RDDSR FLINT analog, as suggested by the decrease of tryptophan

-33-

fluorescence intensity as the concentrations of these cations were increased.

5 Table III. Fluorescence intensity and anisotropy of His-
tagged RDDSR FLINT analog as a function of NiCl_2 , ZnCl_2 , and CaCl_2 ^a

$[\text{NiCl}_2]$ uM	Intens ity	Anisot ropy	$[\text{ZnCl}_2]$ uM	Intensit y	Anisot ropy	$[\text{CaCl}_2]$ uM	Intens ity	Anisot ropy
0	79132	0.124	0	881332	0.144	0	95943	0.135
5	73526	0.132	5	879859	0.132	5	94056	0.133
7	69980	0.133	10	847808	0.136	10	94644	0.135
10	68258	0.129	20	821780	0.152	20	93755	0.133
20	68581	0.134	40	813852	0.186	40	87293	0.126
40	66791	0.137	80	780568	0.213	80	84960	0.133
80	64583	0.136	+ 1mM EDTA	739379	0.126	100	80533	0.132
100	63579	0.137				200	77832	0.136
200	60771	0.137				400	70858	0.135
400	1	5				9	9	9

^a Titration of ZnCl_2 was performed in 20 mM Tris, 150 mM NaCl at pH 7.4.

These examples show that divalent cations, such as Ni^{2+} , Zn^{2+} , and Ca^{2+} , interact with FLINT and FLINT analogs. The effect of these cations on the protein appears to be dependent on the nature of the analog. Both Ni^{2+} and Zn^{2+} induce association of FLINT molecules. Zn^{2+} causes

-34-

reversible precipitation and can be used in the purification of His-tagged FLINT and analogs.

EXAMPLE 7

5 IMAC Purification of R218Q from 293 EBNA Cells

FLINT analog R218Q was purified by IMAC chromatography from 3.4 liters of cell culture medium harvested from 293 EBNA cells that expressed R218Q. The FLINT analog was eluted from the IMAC column in a buffer containing PBS, 0.5 M NaCl, 10 0.4 M imidazole, pH 7.4. The eluted material was dialyzed against a buffer containing PBS, 0.5 M NaCl, 10% glycerol, pH 7.4. The dialyzed solution turned cloudy suggesting that the protein had precipitated. This was confirmed experimentally by intrinsic tryptophan fluorescence.

15 This problem was resolved by resuspending the precipitated protein in PBS, 0.5 M NaCl, 10% glycerol, pH 7.4 and adding EDTA to a final concentration of 50 mM. The precipitated protein went back into solution as observed by visual observation and confirmed by tryptophan fluorescence.

20

-35-

What is claimed is:

1. A composition comprising a divalent metal cation and a FLINT analog.
- 5
2. A composition as in claim 1 wherein said cation is selected from the group consisting of Zn^{+2} , Ca^{+2} , Ni^{+2} , Mn^{+2} , Fe^{+2} , Co^{+2} , and Cd^{+2} .
- 10 3. A composition of Claim 1, wherein the divalent metal cation is Zn^{+2} .
4. A composition of Claim 1, wherein the analog comprises a FLINT glycosylation mutant.
- 15 5. A pharmaceutical formulation comprising a composition of claim 1 in combination with one or more pharmaceutically acceptable carriers, diluents, or excipients.
- 20 6. A formulation of Claim 5, wherein the total cation concentration is 0.001 to 5.0 mg/mL.
7. A formulation of Claim 6, wherein the total cation concentration is 0.05 to 1.5 mg/mL.
- 25 8. A process for reducing aggregation of a FLINT analog molecule comprising the step of removing divalent metal cation.
- 30 9. A process as in claim 8 wherein said FLINT analog molecule is in solution.

-36-

10. A process as in claim 8 wherein said cation is removed by EDTA.
11. A method for inducing oligomerization of a FLINT analog 5 molecule comprising the step of adding divalent metal cation.
12. A method for inducing aggregation of a FLINT analog molecule comprising the step of adding divalent metal 10 cation until said analog precipitates.

SEQUENCE LISTINGTM

<110> Witcher, Derrick
Tian, Yu
Atkinson, Paul

<120> FLINT Analog Compounds and Formulations Thereof

<130> X-13469

<140>
<141>

<160> 3

<170> PatentIn Ver. 2.0

<210> 1
<211> 271
<212> PRT
<213> Homo sapiens

<400> 1
Val Ala Glu Thr Pro Thr Tyr Pro Trp Arg Asp Ala Glu Thr Gly Glu
1 5 10 15
Arg Leu Val Cys Ala Gln Cys Pro Pro Gly Thr Phe Val Gln Arg Pro
20 25 30
Cys Arg Arg Asp Ser Pro Thr Thr Cys Gly Pro Cys Pro Pro Arg His
35 40 45
Tyr Thr Gln Phe Trp Asn Tyr Leu Glu Arg Cys Arg Tyr Cys Asn Val
50 55 60
Leu Cys Gly Glu Arg Glu Glu Ala Arg Ala Cys His Ala Thr His
65 70 75 80
Asn Arg Ala Cys Arg Cys Arg Thr Gly Phe Phe Ala His Ala Gly Phe
85 90 95
Cys Leu Glu His Ala Ser Cys Pro Pro Gly Ala Gly Val Ile Ala Pro
100 105 110
Gly Thr Pro Ser Gln Asn Thr Gln Cys Gln Pro Cys Pro Pro Gly Thr
115 120 125
Phe Ser Ala Ser Ser Ser Ser Glu Gln Cys Gln Pro His Arg Asn
130 135 140
Cys Thr Ala Leu Gly Leu Ala Leu Asn Val Pro Gly Ser Ser Ser His
145 150 155 160
Asp Thr Leu Cys Thr Ser Cys Thr Gly Phe Pro Leu Ser Thr Arg Val
165 170 175
Pro Gly Ala Glu Glu Cys Glu Arg Ala Val Ile Asp Phe Val Ala Phe
180 185 190

Gln Asp Ile Ser Ile Lys Arg Leu Gln Arg Leu Leu Gln Ala Leu Glu
 195 200 205

Ala Pro Glu Gly Trp Gly Pro Thr Pro Arg Ala Gly Arg Ala Ala Leu
 210 215 220

Gln Leu Lys Leu Arg Arg Arg Leu Thr Glu Leu Leu Gly Ala Gln Asp
 225 230 235 240

Gly Ala Leu Leu Val Arg Leu Leu Gln Ala Leu Arg Val Ala Arg Met
 245 250 255

Pro Gly Leu Glu Arg Ser Val Arg Glu Arg Phe Leu Pro Val His
 260 265 270

<210> 2

<211> 300

<212> PRT

<213> Homo sapiens

<400> 3

Met Arg Ala Leu Glu Gly Pro Gly Leu Ser Leu Leu Cys Leu Val Leu
 1 5 10 15

Ala Leu Pro Ala Leu Leu Pro Val Pro Ala Val Arg Gly Val Ala Glu
 20 25 30

Thr Pro Thr Tyr Pro Trp Arg Asp Ala Glu Thr Gly Glu Arg Leu Val
 35 40 45

Cys Ala Gln Cys Pro Pro Gly Thr Phe Val Gln Arg Pro Cys Arg Arg
 50 55 60

Asp Ser Pro Thr Thr Cys Gly Pro Cys Pro Pro Arg His Tyr Thr Gln
 65 70 75 80

Phe Trp Asn Tyr Leu Glu Arg Cys Arg Tyr Cys Asn Val Leu Cys Gly
 85 90 95

Glu Arg Glu Glu Ala Arg Ala Cys His Ala Thr His Asn Arg Ala
 100 105 110

Cys Arg Cys Arg Thr Gly Phe Phe Ala His Ala Gly Phe Cys Leu Glu
 115 120 125

His Ala Ser Cys Pro Pro Gly Ala Gly Val Ile Ala Pro Gly Thr Pro
 130 135 140

Ser Gln Asn Thr Gln Cys Gln Pro Cys Pro Pro Gly Thr Phe Ser Ala
 145 150 155 160

Ser Ser Ser Ser Glu Gln Cys Gln Pro His Arg Asn Cys Thr Ala
 165 170 175

Leu Gly Leu Ala Leu Asn Val Pro Gly Ser Ser Ser His Asp Thr Leu
 180 185 190

Cys Thr Ser Cys Thr Gly Phe Pro Leu Ser Thr Arg Val Pro Gly Ala

195	200	205													
Glu	Glu	Cys	Glu	Arg	Ala	Val	Ile	Asp	Phe	Val	Ala	Phe	Gln	Asp	Ile
210															
Ser	Ile	Lys	Arg	Leu	Gln	Arg	Leu	Leu	Gln	Ala	Leu	Glu	Ala	Pro	Glu
225															
Gly	Trp	Gly	Pro	Thr	Pro	Arg	Ala	Gly	Arg	Ala	Ala	Leu	Gln	Leu	Lys
245															
Leu	Arg	Arg	Arg	Leu	Thr	Glu	Leu	Leu	Gly	Ala	Gln	Asp	Gly	Ala	Leu
260															
Leu	Val	Arg	Leu	Leu	Gln	Ala	Leu	Arg	Val	Ala	Arg	Met	Pro	Gly	Leu
275															
Glu	Arg	Ser	Val	Arg	Glu	Arg	Phe	Leu	Pro	Val	His				
290															
295															
300															

<210> 3
 <211> 936
 <212> DNA
 <213> Homo sapiens

<220>
 <221> CDS
 <222> (25)..(924)

<400> 3																					
gctctccctg	ctccagcaag	gacc	atg	agg	gcg	ctg	gag	ggg	cca	ggc	ctg				51						
												Met	Arg	Ala	Leu	Glu	Gly	Pro	Gly	Leu	
												1			5						
tcg	ctg	ctg	tgc	ctg	gtg	ttg	gcg	ctg	cct	gcc	ctg	ctg	ccg	gtg	ccg						99
Ser	Leu	Leu	Cys	Leu	Val	Leu	Ala	Leu	Pro	Ala	Leu	Leu	Pro	Val	Pro						
10																					25
15																					
30																					
35																					
40																					
gag	aca	ggg	gag	cg	ctg	gtg	tgc	gcc	cag	tgc	ccc	cca	ggc	acc	ttt						195
Glu	Thr	Gly	Glu	Arg	Leu	Val	Cys	Ala	Gln	Cys	Pro	Pro	Gly	Thr	Phe						
45																					
50																					
55																					
gtg	cag	cg	cc	tgc	cgc	cga	gac	ccc	ac	tg	tg	gg	cc	tg							243
Val	Gln	Arg	Pro	Cys	Arg	Arg	Asp	Ser	Pro	Thr	Thr	Cys	Gly	Pro	Cys						
60																					
65																					
70																					
cca	ccg	cg	cac	tac	ac	cg	ttc	tgg	aa	tac	ctg	gag	cg	tgc	cg						291
Pro	Pro	Arg	His	Tyr	Thr	Gln	Phe	Trp	Asn	Tyr	Leu	Glu	Arg	Cys	Arg						
75																					
80																					
85																					
tac	tgc	aa	gtc	ctc	tgc	ggg	gag	cgt	gag	gag	gca	cg	g	tgc	tg						339
Tyr	Cys	Asn	Val	Leu	Cys	Gly	Glu	Arg	Glu	Glu	Glu	Ala	Arg	Ala	Cys						
90																					
95																					
100																					
105																					

cac gcc acc cac aac cgt gcc tgc cgc tgc cgc acc ggc ttc ttc gcg 387
 His Ala Thr His Asn Arg Ala Cys Arg Cys Arg Thr Gly Phe Phe Ala
 110 115 120

cac gct ggt ttc tgc ttg gag cac gca tcg tgt cca cct ggt gcc ggc 435
 His Ala Gly Phe Cys Leu Glu His Ala Ser Cys Pro Pro Gly Ala Gly
 125 130 135

gtg att gcc ccg ggc acc ccc agc cag aac acg cag tgc cag ccg tgc 483
 Val Ile Ala Pro Gly Thr Pro Ser Gln Asn Thr Gln Cys Gln Pro Cys
 140 145 150

ccc cca ggc acc ttc tca gcc agc agc tcc agc tca gag cag tgc cag 531
 Pro Pro Gly Thr Phe Ser Ala Ser Ser Ser Ser Glu Gln Cys Gln
 155 160 165

ccc cac cgc aac tgc acg gcc ctg ggc ctg gcc ctc att gtg cca ggc 579
 Pro His Arg Asn Cys Thr Ala Leu Gly Leu Ala Leu Ile Val Pro Gly
 170 175 180 185

tct tcc tcc cat gac acc ctg tgc acc agc tgc act ggc ttc ccc ctc 627
 Ser Ser Ser His Asp Thr Leu Cys Thr Ser Cys Thr Gly Phe Pro Leu
 190 195 200

agc acc agg gta cca gga gct gag gag tgt gag cgt gcc gtc atc gac 675
 Ser Thr Arg Val Pro Gly Ala Glu Glu Cys Glu Arg Ala Val Ile Asp
 205 210 215

ttt gtg gct ttc cag gac atc tcc atc aag agg ctg cag cgg ctg ctg 723
 Phe Val Ala Phe Gln Asp Ile Ser Ile Lys Arg Leu Gln Arg Leu Leu
 220 225 230

cag gcc ctc gag gcc ccg gag ggc tgg gct ccg aca cca agg gcg ggc 771
 Gln Ala Leu Glu Ala Pro Glu Gly Trp Ala Pro Thr Pro Arg Ala Gly
 235 240 245

cgc gcc ttg cag ctg aag ctg cgt cgg cgg ctc acg gag ctc ctg 819
 Arg Ala Ala Leu Gln Leu Lys Leu Arg Arg Arg Leu Thr Glu Leu Leu
 250 255 260

ggg gcg cag gac ggg gcg ctg ctg cgg ctg ctg cag gcg ctg cgc 867
 Gly Ala Gln Asp Gly Ala Leu Leu Val Arg Leu Leu Gln Ala Leu Arg
 270 275 280

gtg gcc agg atg ccc ggg ctg gag cgg agc gtc cgt gag cgc ttc ctc 915
 Val Ala Arg Met Pro Gly Leu Glu Arg Ser Val Arg Glu Arg Phe Leu
 285 290 295

cct gtg cac tgatcctggc cc 936
 Pro Val His
 300

INTERNATIONAL SEARCH REPORT

Int'l. Appl. No.

PCT/US 00/20807

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 C07K14/705 C07K1/14 A61K38/17 A61K47/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 7 C07K A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO 98 30694 A (HUMAN GENOME SCIENCES INC ; FENG PING (US); NI JIAN (US); EBNER REI) 16 July 1998 (1998-07-16) abstract page 42, line 11 - line 22 page 47, line 3 - line 20 sequence of TNFR-6</p> <p>---</p> <p>WO 99 14330 A (GENENTECH INC) 25 March 1999 (1999-03-25) abstract</p> <p>-----</p>	1-21
A		1-21

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

& document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

11 December 2000

15/12/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Galli, I

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int'l. Appl. No

PCT/US 00/20807

Patent document cited in search report	Publication date	Patent family member(s)			Publication date
WO 9830694	A	16-07-1998	AU	5815798 A	03-08-1998
			AU	6238698 A	03-08-1998
			BR	9806954 A	21-03-2000
			CN	1247567 T	15-03-2000
			EP	1007659 A	14-06-2000
			EP	0990031 A	05-04-2000
			WO	9830693 A	16-07-1998
WO 9914330		25-03-1999	AU	9497098 A	05-04-1999
			EP	1015587 A	05-07-2000